

Distributional and Risk Reduction Effects of Commodity Revenue Program Design*

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One of the purposes of U.S. agricultural programs has been to support or stabilize farm incomes by mitigating the effects of low crop prices and yields. Commodity programs such as the counter-cyclical payment and Marketing Loan programs have provided benefits or made payments to producers of several major field crops when crop prices fall short of expected or target levels. At the same time, the federal crop insurance program has provided support that has focused on yield shortfalls but has increasingly included revenue coverage.

Several proposals to reform U.S. commodity programs have received attention in the 2007 farm bill debate (American Farmland Trust; National Association of Corn Growers; USDA). Generally, these proposals would alter or replace commodity price programs with programs that would make payments when revenues, that is, prices multiplied by yields, fall short of expected or target levels (Coble, Dismukes, and Thomas). Interest in revenue as the basis for farm programs is not new. In 1983, a national-level revenue program was studied as a way to control federal outlays for commodity programs (CBO). In the early 1990s, a regional-level revenue program was analyzed as a way to mitigate the need for supplemental, ad hoc disaster payments (Miranda and Glauber). More recently, a county-level revenue guarantee program has been promoted as providing protection when it is needed while reducing the chances that annual payments would exceed domestic commodity support limits allowed under the World Trade Organization Agreement on Agriculture (Babcock and Hart).

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Along with the increased interest in commodity-specific revenue payment programs, crop revenue insurance, introduced in the 1990s, has grown to become a large part of the federal crop insurance program. Crop revenue insurance differs from crop yield insurance in that it covers shortfalls from expected revenue, measured with farm-level or county yields and futures market prices, rather than shortfalls from expected yield. Revenue insurance has been promoted as way to facilitate forward contracting and to help farmers manage the risk exposure from the switch to direct, fixed commodity payments that began under the 1996 farm bill (Hennessy, Babcock, and Hayes). Like yield insurance, revenue insurance is subsidized; participating producers pay less than 40% of the actuarially based cost of the insurance coverage. In 2007, revenue insurance accounted for more than half of all acreage insured under the federal crop insurance program, including about 70% of the insured acreage of corn, soybeans, and wheat and about 50% of the insured acreage of cotton.

As a commodity revenue payment program might cover portions of producers' risks that are already covered by subsidized revenue insurance, questions arise as to how to integrate the coverage under the two programs. One approach would be to offer revenue insurance that would "wrap around" the revenue program coverage. By this we mean that any payment from the commodity revenue program would be deducted from a crop revenue insurance indemnity and insurance premiums would be reduced to reflect the "wrapping."

In this article, we construct a simulation model to analyze the effects of various revenue program designs on crop revenue variability and how these effects vary across crops and regions. We examine the distributional effects, across crops and counties, of alternative programs that would make payments to producers on shortfalls from expected revenue measured at the county, state and national levels for corn, soybeans, wheat, and cotton—crops that account for about 80% of payments under current commodity programs. We also examine the effectiveness of these alternative programs in reducing producer risk.

Model Structure and Data

Revenue variability depends on variability of crop yields, prices, and their interactions. Both yields and prices are random variables that are potentially correlated with each other. The nature of the randomness in crop prices and yields is quite distinct, however. Because of potential arbitrage, agricultural crop prices are highly spatially correlated (Dismukes and Coble). Thus, price variability for a particular crop is similar across most regions of the U.S. In contrast, yield variability depends on factors such as weather, disease, and insects, which may be widespread or localized. As a result, crop revenue behaves quite differently than price, the random variable underlying commodity programs.

To measure yield variability at the county, state, and national levels we used data from USDA's National Agricultural Statistics Service (NASS). We estimated a linear time trend for each yield data series, 1975–2004, and calculated variability from the residuals relative the predicted yield for 2007. From detrended national, state, and county yield series and data from the federal crop insurance program, we computed farm yield variability for a representative

farm in each county. The representative farm was assumed to have a mean yield equal to the expected county yield and yield variability consistent with the average riskiness of the yields for farms participating in the federal crop insurance program (Coble, Heifner, and Zuniga).

We modeled farm yield according to Miranda's formulation:

$$(1) \quad \tilde{Y}_{ft} = \mu_f + \beta_f(\tilde{y}_{ct} - \mu_c) + \varepsilon_{ft}$$

where \tilde{Y}_{ft} is random farm yield in period t , μ_f is the expected farm yield, \tilde{Y}_{ct} is the random county yield in period t and μ_c is the expected county yield. The coefficient, β_f measures the responsiveness of farm yield to deviations from expected county yield, and ε_{ft} represents the idiosyncratic risk that Miranda shows to be orthogonal to county yield deviations. In our analysis we assumed $\varepsilon_f \sim N(0,k)$ where k represents the standard deviation of the idiosyncratic farm yield risk. For representative farms, it was assumed that $\beta = 1$. Miranda shows that if the county yield were truly an aggregation of all farms in the county, then our assumed $\beta = 1$ would be the acreage weighted average of all β 's in the county.

In order to estimate the farm idiosyncratic risk we conducted a grid search for values of k , by inserting equation (1) into equation (2), which simulates RMA crop insurance premium rates

$$(2) \quad \text{Min } |PR_{65} - ELC_k|, \quad \text{where} \quad ELC_k = E \left[\frac{P_g(C\mu_f - \tilde{y}_{ft_k})}{P_g C \mu_f} \right].$$

PR_{65} is the average effective premium rate for 65% coverage crop yield insurance in each county, while ELC_k is the simulated expected loss cost given a standard deviation of k . The expected loss cost was derived by comparing the ratio of indemnities conditioned on the program parameters price guarantee, P_g , and C , the coverage level. Given C set to 0.65, we searched for the value of k that minimizes equation (2) using a grid search from 10.0 to 60.0 by intervals of 2.¹ Once the standard deviation of idiosyncratic farm yield is obtained farm yields can be simulated. Finally, the matrix $[Y]$ is created, which has national, state, and county yield deviations for each of the four crops. Thus the matrix has T rows representing historical yields.

We estimated price variability from NASS data. National annual marketing-year average (MYA) prices for 1974 through 2005 were used. State basis adjustments from the national price were also derived from the historical data. These data were used to estimate a percentage price change from the previous year's price level. The data for the four crops are maintained in the matrix $[P]$ that also has T rows for historical year.

Our simulations make 500 random draws of a five-year time path. Yield deviations from trend and price changes from the previous year for every location are drawn simultaneously to maintain empirical correlations between prices and yields and between yields at different levels of aggregation. The idiosyncratic portion of farm yield is independently drawn for each representative farm. Starting prices for the simulations are determined from December 2007 futures market prices, from the Chicago Board of Trade for corn

and soybeans, from the Kansas City Board of Trade for wheat, and from the New York Board of Trade for cotton, for 2008 delivery months. The MYA price is obtained by taking the relative price change associated with the randomly drawn yield shock and multiplying by the previous year's MYA price. State prices are obtained by adjusting national price for a regional basis.

Alternatives Modeled

We model four sets of price, yield, and revenue programs. The first set, which represents current farm programs and provides a basis for comparisons of alternatives, is composed of the price-based commodity programs provided under the 2002 farm bill—the direct payment (DP) and the counter-cyclical payment (CCP) programs and the loan deficiency program (LDP)—plus revenue coverage under the federal crop insurance program. The three alternative sets of programs replace the price CCP program with revenue counter-cyclical payment (RCCP) programs that are based on county, state, and national revenue. The revenue programs would provide a guarantee of 90% of expected revenue, measured by preplanting futures market prices and yields at the county, state, and national levels. In each of the three alternative sets a farm-level revenue insurance policy is wrapped around the area revenue payment coverage.

We calculated the direct payments under 2002 farm bill programs as follows

$$(3) \quad DP = \bar{y}_f \times DP_R \times 85\% \times BA$$

where \bar{y}_f is the program yield, DP_R is defined as the DP rate, and BA is the base acreage. The CCP is

$$(4) \quad CCP = (CCP_{TP} - DP_R - \max(LR, MYA)) \times 85\% \times BA \times \bar{y}_f$$

where CCP_{TP} is the target price, and all other variables are as defined previously. The LDP is

$$(5) \quad LDPs = y_f \times \max(0, LR - MYA) * PA$$

where LR is the loan rate and PA represents planted acres.² The values for the program parameters for each crop are as defined in legislation (Economic Research Service, USDA). Data on planted acres were obtained from NASS for the 2005 crop year. Base acres were obtained from USDA's Farm Service Agency for each county for 2002. Program yields were derived by comparing the national average program yield to the expected yield. This ratio was applied to the 2007 expected yield for each county.

The revenue insurance payment was calculated as the expected net indemnity—indemnity minus subsidized premium—for a crop revenue insurance policy based on planted acre yields not program yields and base acres that are used for DPs and CCPs. The revenue insurance coverage is 65% of expected revenue for the crop at the farm level and includes the upside price coverage that is used in the crop revenue coverage insurance policies.³

The RCCP programs—county, state, and national revenue programs—in the alternatives of farm programs would use the same base acres and programs yields as the price-based CCP. The revenue payment trigger is

$$(6) \quad RCCP_j = 85\% \times BA \times \bar{Y}_f \times \text{Max} \left[0, \left(\frac{EP * \bar{y}_j - MYA * y_j}{\bar{y}_j} \right) \right].$$

The RCCP payment equals the product of 85%, the farm's base acres, the farm's CCP program yield, and the RCCP payment rate. The RCCP payment rate is calculated as the maximum of zero or the value obtained by dividing the expected revenue, based on futures market price, minus the realized revenue, divided by the payment yield, \bar{y}_j . The j subscript denotes national, state, or county levels of aggregation.

In our alternatives we include the net benefit of crop revenue insurance for a farm-level commodity revenue insurance product with 65% coverage and upside price protection wrapped around the RCCP. The insurance benefit is calculated as

$$(7) \quad RIWrap = \text{max}[0, ((65\% \times APH_f \times \text{max}(EP, HP)) - (y_f HP + RCCP_j))]$$

where APH_f is the farm's crop insurance actual production history yield, EP is the crop revenue insurance preplanting expected price, and HP is the crop revenue insurance harvest price. The wrapping of insurance around the revenue program is achieved by adding any RCCP payments to market revenue before calculating the crop insurance indemnity. If the revenue insurance were not wrapped, RCCP would be omitted from the equation.

Results

First, we examine the average annual payment under the three alternative sets of programs relative to current programs. The alternatives replace CCP with RCCP. RCCPs are the difference between actual revenue and 90% of expected revenue at the national, state, and county levels. The current and the alternative sets of programs include DP and LDP, as currently defined in legislation. The current programs include a crop revenue insurance policy similar to that available under the federal crop insurance program; the alternatives include crop revenue insurance wrapped around the RCCP. Table 1, panel (a) shows that, under our simulations, the current set of programs would pay a producer an average of less than \$27 per acre for soybeans and for wheat and slightly less than \$48 for corn. Payments for cotton, about \$105, are more than double per acre corn payments, reflecting higher DPs as well as market prices that result in relatively more frequent LDPs and CCPs.

Moving to the revenue-triggered alternatives would result in increased average payments for corn, soybeans, and wheat, but lower payments for cotton. This largely stems from the current market price expectations far exceeding trigger levels of the current programs for the first three crops. In effect, a guarantee of 90% of expected revenue uses a price well above the current program price. But other factors come into play as well. The distribution

Table 1. Average annual payment from current and alternative sets of programs

Programs	Crop			
	Corn	Soybeans	Wheat	Cotton
1a.	<i>Annual payments per acre*</i>			
Current programs	47.99	26.60	26.58	104.73
Alternative set of programs with revenue payment based at following levels:				
National	49.83	28.64	29.28	84.25
State	51.42	29.41	33.96	87.57
County	53.49	30.37	35.92	90.71
1b.	<i>Percentage risk reduction relative to no program**</i>			
Current Programs	41.31	16.49	17.82	28.10
Alternative set of programs with revenue payment based at following levels:				
National	40.20	16.59	20.63	26.73
State	40.73	16.99	20.18	27.47
County	41.15	17.41	21.39	28.65
1c.	<i>Percentage reduction in "wrapped" revenue insurance rates***</i>			
National	6.56	6.14	16.92	9.76
State	12.42	8.68	19.60	12.27
County	18.34	11.99	24.91	18.34

Notes: * All sets of programs include DP and Marketing Loan Payments. Current programs also included price-based CCP and crop revenue insurance net indemnities. In alternative sets of programs revenue-based CCP replace price-based CCP and crop revenue insurance is wrapped around revenue payments.

**Reduction is decrease in coefficient of variation of revenue relative to no programs. Programs include DP, Marketing Loan Payments and crop revenue insurance. Crop revenue insurance is wrapped around revenue payment in the alternative sets of programs.

***Rate reduction is percentage decrease relative to current revenue insurance rate.

of revenue differs from the price distribution; revenue can be more variable than price, especially when disaggregated to the state or county level (Coble, Dismukes, and Thomas).

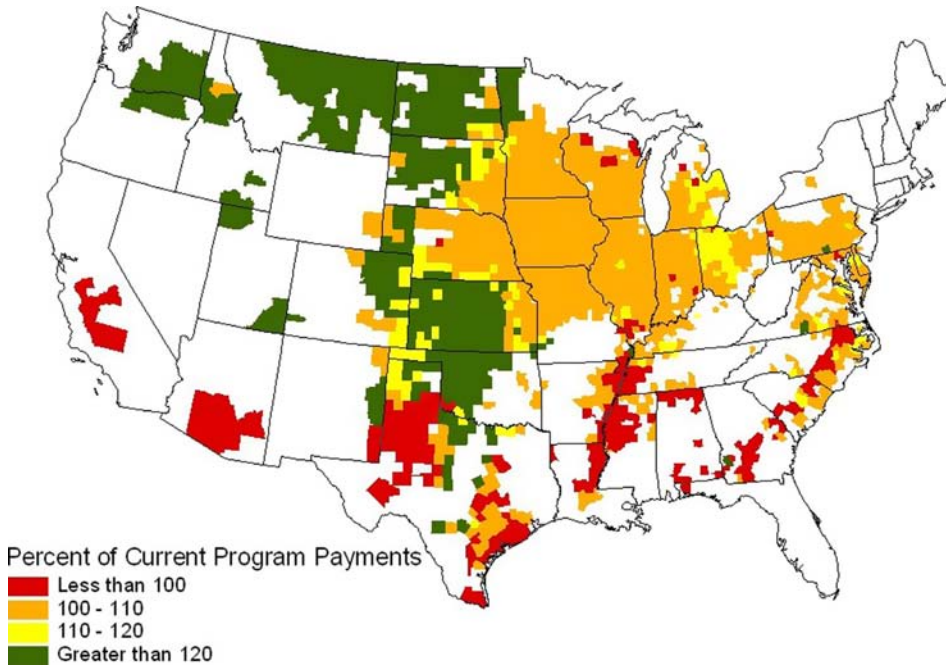
As one looks at the three revenue program alternatives, average payments for each crop tend to increase as the level at which the revenue guarantee is made becomes more spatially disaggregated. This is because revenue variability is greater at the state level than at the national level and greater at the county level than at the state level. For corn, soybeans, and cotton, average payments would be about 3 to 4% higher under the state-level revenue alternative than under the national-level revenue alternative, while average payments for wheat would be about 16% higher, reflecting the diversification of wheat production risk across geographic regions. Comparing average payments from the county-level revenue alternative to the national level alternative payments would be about 6 to 8% higher for corn, soybeans, and cotton and about 23% higher for wheat.

Average payment to a producer is only one measure of the effectiveness of a set of programs; risk reduction is also important. We measure the risk reduction for the alternative sets of programs as simply the percentage change in the coefficient of variation of revenue from the no program coefficient of variation. Table 1, panel (b) reports the results of this analysis of producer risk reduction resulting from current programs and the three alternative revenue-triggered programs for each of the four crops. While the average level of risk reduction varies across crops, the general level of risk reduction from different programs is relatively close. For all crops risk reduction is the greatest among the revenue-based alternatives under a program based on county-level revenue. For cotton, national and state triggers reduce less risk than current programs but a county-triggered program out-performs current programs. One might expect greater differences in risk reduction between the national-, state-, and county-triggered programs, but these differences are dampened by the other programs such as crop revenue insurance, which can compensate for risk that a more aggregate revenue-triggered program would fail to mitigate.

The risk reductions for the RCCP alternatives are also indicated by the reduction in premium rates for revenue insurance that would result from combining or wrapping revenue insurance around the revenue payment. Table 1, panel (c) shows the average reduction in revenue insurance rates for each of the four crops given that crop revenue insurance is wrapped around the national, state, and county programs. Note that the revenue insurance coverage modeled differs from the aggregate revenue programs in that the insurance is based on planted rather than base acres and the insurance has upside price protection not provided with the RCCPs. Both these factors, in addition to the spatial aggregation, reduce the correlation of revenue insurance indemnities and RCCPs. Furthermore, the crop revenue insurance level, 65% of expected revenue, is lower than the 90% guarantee of the RCCPs. Table 1, panel (c) shows that for each crop, moving to smaller spatial units for the RCCP increases the reduction in the crop revenue insurance rates. Among the four crops, the national-level revenue program would have the greatest effect on insurance rates for wheat, about 17%, and the least for corn and soybeans, about 6%. The rate reduction increases for each of the crops as one moves from the national to the state-level revenue program. For a county-level revenue program, the rate reduction ranges from about 12% for soybeans to about 25% for wheat.

Thus far our results have been for national averages for each of the four crops. Because revenue variability differs across regions it is important to look at the spatial distribution of payments. Figure 1 shows a county breakout of the percentage change in payments per acre that would be expected if programs were modified to include the modeled state revenue design rather than the current national price-triggered CCP. The values reflect the sum of payments in the county for the four crops modeled. The map shows that counties in most southern states would receive lower payments. This is largely due to the reduced payments for cotton. In contrast, the largest gains in payments would be in regions dominated by wheat. This is most obvious in Kansas and Oklahoma and in the northern tier of states running from North Dakota to Washington. The heart of the Cornbelt would receive payments near current levels.

Figure 1. Payments under alternative set of programs including state-level RCCP programs relative to current programs, corn, soybeans, wheat, and cotton



Figures 2 and 3 contrast the payments from the national- and county-triggered revenue programs for corn. First, the national revenue-triggered program clearly provides the greatest benefit to high yielding regions (i.e., the heart of the Cornbelt and in irrigated plains counties). In these counties the county-level revenue risk is similar to the national revenue while county yields are higher than the national yield. The county program results in figure 3 also show much higher payments in lower yield regions, which arise from the greater riskiness of yields in these counties.

Figure 4 illustrates the regional distribution of the rate reduction arising from wrapping insurance around a state revenue program. In general, the rate reduction in our simulations would be at least 20% in the Cornbelt, but less than 20% in other areas. These results are largely driven by the homogeneity of yield risk within the state. States such as Iowa and Illinois are more homogenous regions than states on the fringe of the Cornbelt or geographical diverse states such as Texas.

Conclusions/Implications

The 2007 farm bill debate has developed in the context of high market prices for most program crops, tight fiscal limits, and increased pressure for program reform. Out of this milieu, revenue-triggered programs have been one of the

Figure 2. Regional distribution of national-level RCCP, corn

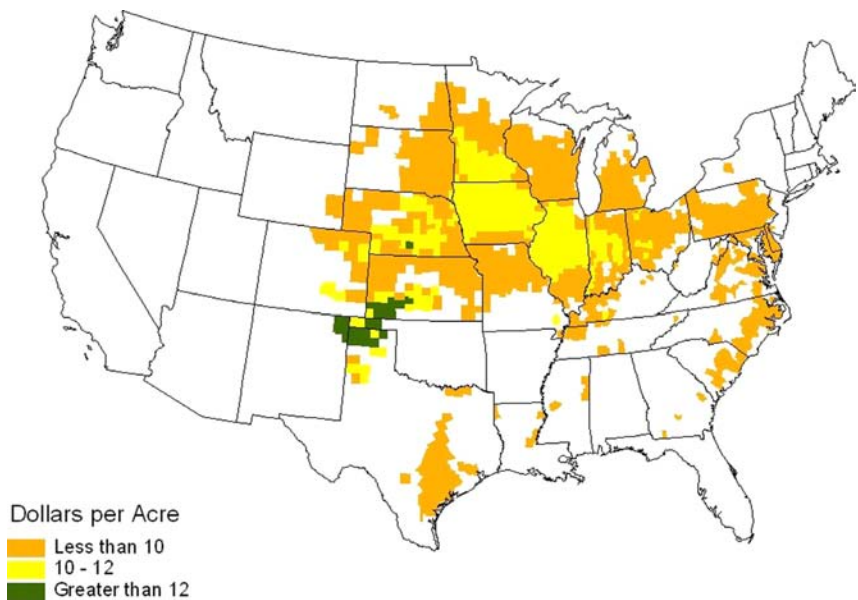


Figure 3. Regional distribution of county-level RCCP, corn

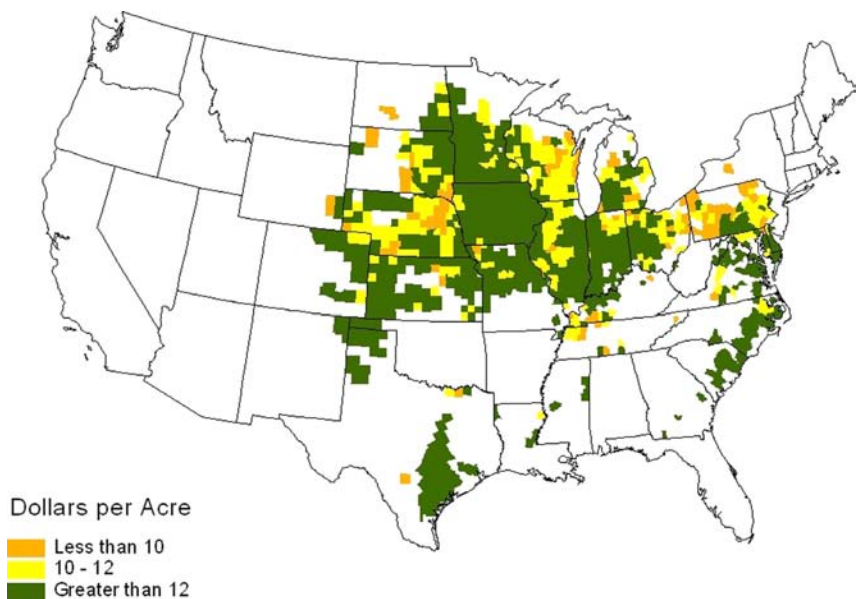
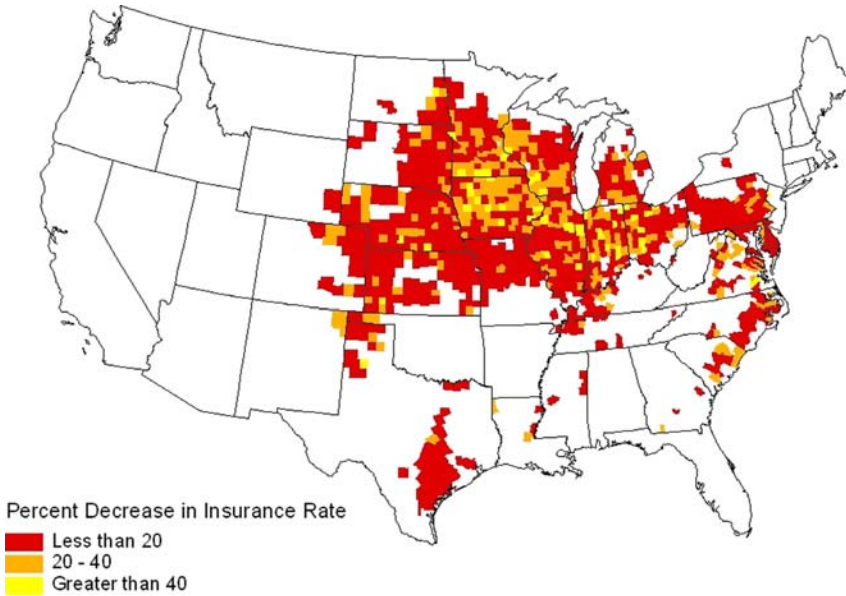


Figure 4. Rate reduction for revenue insurance wrapped around state-level RCCP, corn



most prominent proposals for reform. In this article, we examine a set of alternative designs that use revenue triggering at various levels of aggregation. Our results show that revenue is a fundamentally different random variable than price. Because revenue subsumes yield risk it captures a “natural hedge” between price and yield. While the natural hedge is substantial in Midwestern corn, it is essentially nonexistent in other crops and regions.

A move to revenue-based programs would not necessarily increase or decrease government expenditures relative to current programs. Factors that would drive the program costs include the level of aggregation and current price levels relative to prices used to set revenue guarantees. The geographic level at which revenue would be measured is also important. More disaggregated revenue programs will cost more on average and will direct more of government payments to riskier regions. These concerns appear not to have been widely considered in the current debate.

A related issue is the cost effectiveness of government programs in reducing risk. Our models allow examination of this issue and point out that while revenue programs could be more efficient in reducing risk than separate price and yield risk instruments, when the proposed revenue programs are layered with other programs such as LDPs and crop insurance much of that efficiency is lost. As a result, we do not find dramatic differences in the risk reduction achieved by the alternatives examined in this article.

One means to increase risk reduction efficiency is to wrap insurance around more aggregate risk programs. Our results show a reduction in the actuarially fair premium rates for crop revenue insurance and show that the reduction

increases as the revenue program is disaggregated from the national to the county level. It is important to note that reducing rates under the current federal crop insurance program implies a reduction in program delivery costs, including the administrative and operating subsidy, which is currently paid to private crop insurance companies based on shares of premiums.

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Endnotes

¹Crop insurance is generally sold at the basic or optional unit level, which is typically more disaggregated than the farm. Thus, the effective premium rate data are largely a mix of basic and optional unit rates and captures some other risks that might not be considered yield risk (i.e., quality loss). The effective premium rates were adjusted downward by 15% to approximate farm-level variability.

²We recognize LDPs are paid based on posted county prices at the time the LDP is exercised. Assuming efficient markets hold, our assumption should not bias the results.

³Individual coverage may also protect crop yields or revenue without the upside price protection. Upside price protection allows the higher of the preplanting or harvest-time futures price to be used in the insurance coverage. Nearly all producers with revenue insurance have chosen the upside price protection. Also, area-based yield and revenue insurance are widely available.

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